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(54) MICROPHONE UNIT WITH INTERNAL A/D CONVERTER
MIKROFONEINHEIT MIT INTERNEM A/D-UMSETZER
UNITE MICROPHONE DOTEE D'UN CONVERTISSEUR A/N INTERNE

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Description

FIELD OF INVENTION

[0001] The present invention relates to a microphone assembly and, in particular, to a microphone assembly comprising a transducer, a pre-amplifier, filter means and an analog-to-digital (A/D) converter in the housing of the microphone assembly.

BACKGROUND OF THE INVENTION

[0002] Currently, a typical microphone assembly used in portable phones (e.g., mobile or cellular phones) converts acoustical signals to analog audio signals, which are transmitted from the microphone assembly along a signal line to an external A/D converter for digitization. As the analog audio signals travel from the microphone assembly to the A/D converter, however, they are undesirably susceptible to electromagnetic interference (EMI) caused by the presence of high frequency signals (normally around 1-2 GHz).

[0003] In order to provide a better protection against EMI the A/D converter may be positioned within an electrically shielded microphone housing also housing the microphone transducer. Hereby, it is possible to provide a high sound quality without disturbing noise. A sigma-delta type A/D converter may be chosen for such solutions.

[0004] US 5,796,848 discloses a digital hearing aid with a microphone. In order to avoid EMI an A/D converter is positioned within the microphone casing whereby the A/D converter is shielded against EMI. It is shown in US 5,796,848 that the A/D converter can be a sigma-delta type converter.

[0005] However, in spite of superior EMI protection, microphone assemblies with integrated sigmal-delta converters will, under certain operating conditions, exhibit a sound quality suffering from serious artefacts. The sigma-delta converter may under certain conditions cause clearly audible tone components uncorrelated with the intended audio signal.

[0006] Therefore, in order for the sigma-delta converter to be used for microphone assemblies suitable for applications requiring high sound quality this tonal problem must be solved. It may be seen as an object of the present invention to provide such microphone assembly.

SUMMARY OF THE INVENTION

[0007] The above-mentioned object is provided in a first aspect of the present invention by providing a microphone assembly comprising

- a microphone assembly casing having a sound inlet port,
- a transducer for receiving acoustic waves through the sound inlet port, and for converting received acoustic waves to analog audio signals, said transducer being positioned within the microphone assembly casing,
- an electronic circuit positioned within the microphone assembly casing, said electronic circuit comprising a signal path defined by a cascade of
    - a pre-amplifier for amplifying analog audio signals from the transducer, and
    - a sigma-delta modulator for providing digital audio signals,

characterised in that the microphone assembly further comprises filter means in the signal path between the pre-amplifier and the sigma-delta modulator. Audible spurious tonal phenomena may easily occur in a sigma-delta converter being exposed to an input signal with certain, undesired DC offsets or components that slowly changes. An effective way of eliminating this problem is to avoid such DC or slow varying components in the signal at the input of the sigma-delta converter.

[0008] In the present invention the spurious tone problem is solved by filter means in the signal path between the pre-amplifier and the sigma-delta converter. DC or slow varying components in the signal from the pre-amplifier can be removed or attenuated by the filter means thus avoiding such components at the input of the sigma-delta converter. Preferably, the filter means comprises a high-pass filter implemented as a pure high-pass filter or, alternatively, as a band-pass filter implemented as a high-pass filter and a low-pass filter in combination.

[0009] In order to protect against EMI the microphone assembly casing may be a metallic housing or a housing holding a metallic coating or metallic layer so as to establish a Faraday cage.

[0010] The microphone assembly may in addition comprise a second amplifier between the filter means and the sigma-delta modulator so as to amplify the filtered analog audio signals.

[0011] In order to save space, reduce cost and to minimize exposure of analog signal path's to EMI the pre-amplifier and the sigma-delta modulator are preferably integrated on a chip so as to form an integrated circuit. Such chip may be implemented monolithically so as to form an ASIC. In case the microphone assembly also comprises a high-pass filter, the pre-amplifier, the sigma-delta modulator, and at least part of the high-pass filter may advantageously be integrated on the same chip so as to form a monolithic integrated circuit. Typically, the high-pass filter comprises a resistor and a capacitor, which in combination alone or in combination with other components forms the high-pass filter. The capacitor part of such high-pass filter may advanta-

geously be physically separated from the resistor part. The second amplifier may also form part of the integrated circuit further comprising the pre-amplifier, the filter means and the sigma-delta modulator. The second amplifier may be implemented as e.g. a buffer or a differential converter, such as a single-entity differential converter.

[0012] Alternatively, the pre-amplifier, the sigma-delta modulator, and at least part of the high-pass filter may be implemented on separate chips so as to form separate electronic circuits.

[0013] Typically, the transducer comprises a flexible diaphragm having a pressure-equalizing opening penetrating the diaphragm. This pressure equalizing opening has dimensions so that frequencies in the analog audio signals below a predetermined frequency value are suppressed. Generally speaking, by making the pressure equalizing opening smaller, the cut-off frequency of the acoustic high-pass filter decreases. With a lower cut-off frequency of the acoustic high-pass filter the electronic high-pass filter can be designed with a smaller capacitor without increasing the total noise from the microphone. This design route is of specific importance in the area of hearing aids where space issues within hearing instruments are among the most important design parameters.

[0014] The microphone assembly may further comprise a digital filter connected to the output terminal of the sigma-delta modulator. Preferably, the digital filter is a digital decimation low-pass filter forming part of the integrated circuit.

[0015] The microphone assembly may further comprise a low-pass filter between the pre-amplifier and the analog-to-digital converter so as to low-pass filter amplified analog audio signals to avoid aliasing during the sampling process. Preferably, the transducer is a Silicon (Si) -based transducer comprising a Si back-plate arranged adjacent and substantially parallel to the above-mentioned flexible diaphragm which, preferably, is fabricated from Si. The Si diaphragm and the Si back-plate may form a capacitor in combination so as to form a condenser microphone.

[0016] In a second aspect, the present invention relates to a portable unit comprising

- a microphone assembly according to the first aspect of the present invention, said microphone assembly being connected to digital signal processing means (e.g. a DSP) for further signal processing.

[0017] Since the signal processing outside the microphone assembly is purely digital, the DSP used for the further signal processing is denoted a pure DSP.

[0018] The portable unit may be selected from the group consisting of hearing aids, assistive listening devices, mobile recording units, such as MP3 players; and mobile communication units, such as mobile or cellular phones.

[0019] The inventive combination of the microphone having an internal A/D converter and optionally a pure DSP overcomes several aforementioned disadvantages associated with prior art systems in which DSPs have analog processing capability. By having microphones with digital output that is transmitted from the microphone casing, the inventive microphones promote interchangeability, permitting one microphone assembly to be easily substituted for another. Any adjustments that may be required can be entirely software controlled.

[0020] In addition, the use of a pure DSP simplifies the design of a mobile phone and lowers manufacturing costs because pure DSPs are less expensive to manufacture compared to DSPs which also contain analog circuitry.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The foregoing and other advantages of the invention will become apparent upon reading the following detailed description and upon reference to the following drawings, where

FIG. 1 is a functional diagram of a microphone assembly in accordance with a specific aspect of the present invention and pure DSP, and

FIG. 2 is a functional diagram of a microphone assembly DSP in accordance with another aspect of the present invention and pure digital.

[0022] While the invention is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0023] A first example of use of the microphone assembly according tb the first aspect of the present invention is a mobile phone. A mobile phone generally includes a microphone assembly, a pure digital signal processor (pure DSP), a speaker assembly, an RF receiver unit, an RF transmitter unit, and an antenna. The microphone assembly comprises a microphone assembly casing that houses a transducer, an electronic circuit comprising a pre-amplifier, filter means, and an analog-to-digital (A/D) converter comprising a sigma-delta converter which converts the analog audio signals into a serial digital bit stream. In addition to providing structural integrity to the entire microphone assembly, the microphone assembly casing shields or protects the transducer, the microphone pre-amplifier, the filter means,

and the A/D converter against undesired high frequency EMI. The microphone assembly casing is preferably composed of an electrically conducting material, such as steel or aluminium, or metallized non-conductive materials, such as metal particle-coated plastics.

[0024] Acoustical energy is received through a sound inlet by the transducer. In a preferred embodiment, the transducer comprises an electret assembly that includes a flexible diaphragm that moves in response to exposure to acoustical energy. The movement of the flexible diaphragm results in an electrical signal and, thus, transducer transduces the acoustical energy into electrical energy. This electrical energy is provided as analog audio signals to microphone pre-amplifier, which amplifies the analog audio signals to an appropriate level for the filter means and the A/D converter. The preamplifier may include more than one gain stage. The A/D converter converts the analog audio signals to digital output signals.

[0025] In a preferred embodiment, the A/D converter is implemented as a sigma-delta modulator, which converts the analog audio signals into a serial digital bit stream. Alternatively, the A/D converter may be, for example, a flash or pipeline converter, a successive approximation converter, or any other suitable A/D converter. The serial digital bit stream may be transmitted on a line to a pure DSP for further processing. The pure DSP does not contain analog circuitry and does not process analog signals. Rather, the pure DSP only contains digital circuitry (circuitry that is adapted to only process digital signals) and only processes digital signals. Thus, the input signals on the lines to the pure DSP and the output signals on the lines from the pure DSP are only in a digital format.

[0026] The pure DSP processes the digital output signals from the line from the A/D converter and provides digital signals for transmission on the line to the RF transmitter unit. The RF transmitter unit converts the digital signals for transmission into RF signals, which are transmitted by the antenna. Similarly, the antenna provides RF signals to the RF receiver unit, which provides received digital signals on the line to the pure DSP. The pure DSP processes the received digital signals and provides digital audio output signals on the line to the speaker assembly. The digital audio output signals on the line to the speaker assemblymay be PDM-or PWM-coded signals. The speaker assembly converts the digital audio output signals to acoustical signals that will be heard by the operator.

[0027] The mobile phone is not the only device in which the present invention is operable. The mobile phone was selected for illustration purposes only, and the present invention contemplates many other devices besides mobile phones. Examples of other devices include, without limitation, portable phones, portable audio or video recording systems, hearing aids, personal digital assistants, wearable microphones (wired or wireless), and any other device which requires a microphone that is miniature in size and which requires a raw or formatted digital audio output.

[0028] In FIG. 1 a specific microphone assembly 103 according to the present invention includes a high-pass filter 109 connected between microphone pre-amplifier 110 and A/D converter 112, which is a sigma-delta modulator. The high-pass filter 109 blocks DC or attenuates slow varying components in the signals between microphone pre-amplifier 110 and A/D converter 112. The high-pass filter 109 also reduces the overall noise level in the microphone assembly 103 by filtering out low frequencies. An additional amplifier (not shown) may be connected between high-pass filter 109 and A/D converter 112. This additional amplifier may be a buffer or a differential converter, such as a single-entity differential converter.

[0029] A low-pass filter (not shown) may be connected between pre-amplifier 110 and A/D converter 112. This filter prevents undesired aliasing effects by limiting the frequency content of the signals before they are provided to A/D converter 112. High-pass filter 109 and low-pass filter are preferably incorporated into the microphone pre-amplifier 110 though, alternatively, high-pass filter 109 and low-pass filter may optionally be separate from the microphone pre-amplifier 110. The digital output signals on line 120 are raw signals in the sense that they have not been formatted according to any standard audio format. The raw digital output signals on line 120 are transmitted to the pure DSP 114 for further digital processing. Formatting of the digital output signals is discussed later.

[0030] High-pass filter 109 typically comprises a capacitor and a resistor. The filtering effect of high-pass filter 109 is minimised by selecting capacitor and resistor values making τ as large as possible, or in other word, ensure a very low cut-off frequency of the high-pass filter. Furthermore, it is essential to minimise the noise from the high-pass filter itself. This may be achieved by selecting a large capacitance (e.g. 8 μF) since the electronic noise from a capacitor is given by kT/C, where C is the capacitance, T is the temperature and k Planck's constant. It is clear that the electronic noise from the capacitor increases with a smaller capacitance.

[0031] The characteristics of high-pass filter 109 may be designed by taking into consideration the design of the transducer receiving the acoustic signals. For example, by introducing a small pressure equalisation opening in the flexible diaphragm of the transducer, the cut-off frequency of the acoustic high-pass filter may be lowered down to e.g. 50 Hz. With such a low cut-off frequency, the high-pass filter may be designed with a smaller capacitor without increasing the total noise from the microphone. However, it is still necessary to remove frequencies below 200 Hz electronically so as to avoid overloading the microphone. For this reason high-pass filter 109 is typically designed with a cut-off frequency of around 200 Hz. Following this approach, the acoustic noise from the microphone is minimised. Noise leaking

the acoustic high-pass filter may be filtered out by high-pass filter 109. Removal of the lower frequencies electronically using high-pass filter 109 results in a lower total noise and better matching of the low cut-off frequency.

[0032] The immediate result achieved following the above-mentioned design route is that the physical dimensions the capacitor may be significantly reduced which also means that the overall size of the microphone assembly may be reduced. This size issue is of specific importance in the area of hearing aids.

[0033] An alternative microphone assembly includes a microphone casing that includes transducer, a microphone pre-amplifier, an A/D converter, and a digital filter in accordance with another embodiment of the present invention. The A/D converter is preferably a sigma-delta modulator, and the microphone pre-amplifier may include either a high-pass filter or a low-pass filter or both, as discussed in connection with the embodiment described in FIG. 1. The digital filter removes the high frequency noise from the digital bit stream. For example, the digital filter is preferably a digital decimation low-pass filter, which removes out-of-band quantization noise. In one embodiment the digital filter is within the microphone casing, but it is expressly contemplated that the digital filter may be incorporated in a pure DSP outside the microphone casing. Whether the digital filter is incorporated in the A/D converter or in the pure DSP will depend on size constraints, for example.

[0034] A microphone assembly with a formatting circuit connected between an A/D converter and a pure DSP is in accordance with another embodiment of the present invention. The formatting circuit formats the signals from the A/D converter in accordance with a digital audio standard, such as, for example, S/PDIF, AES/EBU, I²S, or any other suitable digital audio standard. Alternatively, the formatting may be performed by the pure DSP. The formatting circuit is preferably incorporated into the A/D converter within a microphone casing, and may further include a digital filter, like the one described in connection with FIG. 1. The pre-amplifier may include a high-pass filter and/or a low-pass filter like those described in connection with FIG. 1. The formatted digital output signals may be transmitted on a line to the pure DSP for further processing or, because the digital output signals are formatted according to a digital audio standard, may be plugged into or incorporated directly into a device which is compliant with such digital audio standard, such as a portable audio or video device, for example.

[0035] Finally, FIG. 2 shows a microphone assembly 203 having an integrated circuit (IC) 205 connected between transducer 208 and a pure DSP 214. The IC 205 is located within a microphone assembly casing 204 and includes a microphone pre-amplifier 210 and an A/D converter 212, which is preferably a sigma-delta modulator. The IC 205 further includes the high-pass filter 109, or the low-pass filter described in FIG. 1. Optionally, it further includes the additional amplifier described in FIG. 1, a digital filter, or a formatting circuit. Size constraints of the microphone may dictate how many additional components are incorporated on the IC 205. The analog audio signals from transducer 208 are provided to the IC 205 which outputs either raw or formatted digital output signals on line 220 to the pure DSP 214.

[0036] While the microphone assemblies 103, and 203, of FIGS. 1 and 2 have been described in connection with a pure DSP; each assembly can be used with a non-pure DSP having analog capabilities, as well.

[0037] While the present invention has been described with reference to one or more particular embodiments, those skilled in the art will recognize that many changes may be made thereto without departing from the spirit and scope of the present invention. Each of these embodiments and obvious variations thereof is contemplated as falling within the spirit and scope of the claimed invention, which is set forth in the following claims.

Claims

1. A microphone assembly (103) comprising

   - a microphone assembly casing (104) having a sound inlet port (106),
   - a transducer (108) for receiving acoustic waves through the sound inlet port (106), and for converting received acoustic waves to analog audio signals, said transducer (108) being positioned within the microphone assembly casing (104),
   - an electronic circuit positioned within the microphone assembly casing (104), said electronic circuit comprising a signal path defined by a cascade of
     - a pre-amplifier (110) for amplifying analog audio signals from the transducer (108), and
     - a sigma-delta modulator (112) for providing digital audio signals,

   characterised in that the microphone assembly (103) further comprises filter means (109) in the signal path between the pre-amplifier (110) and the sigma-delta modulator (112).

2. A microphone assembly (103) according to claim 1, wherein the filter means (109) in the signal path prevents low frequency components from reaching the sigma-delta modulator (112).

3. A microphone assembly (103) according to claims

1 or 2, wherein the filter means is a high-pass filter (109).

4. A microphone assembly (103) according to claims 1 or 2, wherein the filter means is a band-pass filter.

5. A microphone assembly (103) according to any of claims 1-4, further comprising an amplifier in the signal path between the filter means (109) and the sigma-delta modulator (112) so as to amplify the filtered analog audio signals.

6. A microphone assembly (103) according to any of claims 1-4, wherein the pre-amplifier (110) and the sigma-delta modulator (112) are integrated on a chip so as to form a monolithic integrated circuit.

7. A microphone assembly (103) according to any of claims 1-4, wherein the pre-amplifier (110), the sigma-delta modulator (112), and at least part of the filter means (109) are integrated on a chip so as to form a monolithic integrated circuit.

8. A microphone assembly (103) according to any of claims 1-4, wherein the pre-amplifier (110), the sigma-delta modulator (112), and at least part of the filter means (109) are implemented on separate chips so as to form separate electronic circuits.

9. A microphone assembly (103) according to claim 5, wherein the amplifier forms part of a monolithic integrated circuit further comprising the pre-amplifier (110), at least part of the filter means (109) and the sigma-delta modulator (112).

10. A microphone assembly (103) according to any of the preceding claims, wherein the transducer (108) comprises a flexible diaphragm having a pressure equalizing opening penetrating the diaphragm.

11. A microphone assembly (103) according to claim 10, wherein the pressure equalizing opening has dimensions so that frequencies in the analog audio signals below a predetermined frequency value are suppressed.

12. A microphone assembly (103) according to claim 6 or 7, further comprising a digital filter for receiving data from the sigma-delta modulator (112), said digital filter forming part of the monolithic integrated circuit.

13. A microphone assembly (103) according to claim 12, wherein the digital filter is a digital decimation low-pass filter.

14. A microphone assembly (103) according to any of the preceding claims, wherein the transducer is a Si-based transducer.

15. A portable unit comprising

- a microphone assembly (103) according to any of the preceding claims, said microphone assembly (103) being connected to a pure digital signal processor (114) for further signal processing.

16. A portable unit according to claim 15, wherein the portable unit is selected from the group consisting of hearing aids, assistive listening devices, mobile recording units, such as MP3 players; and mobile communication units, such as mobile or cellular phones.

Patentansprüche

1. Mikrofonanordnung (103) mit
einem Mikrofonanordnungsgehäuse (104) mit einer Schalleinlaßöffnung (106),
einem Wandler (108) zum Empfangen von Schallwellen durch die Schalleinlaßöffnung (106) und zum Umwandeln empfangener Schallwellen in analoge Tonsignale, wobei der Wandler (108) im Mikrofonanordnungsgehäuse (104) positioniert ist,
einer elektronischen Schaltung, die im Mikrofonanordnungsgehäuse (104) positioniert ist, wobei die elektronische Schaltung einen Signalweg aufweist, der durch eine Kaskade aus folgendem gebildet ist:

einem Vorverstärker (110) zum Verstärken analoger Tonsignale vom Wandler (108), und einem Sigma-Delta-Modulator (112) zum Bereitstellen digitaler Tonsignale,

dadurch gekennzeichnet, daß die Mikrofonanordnung (103) ferner eine Filtereinrichtung (109) im Signalweg zwischen dem Vorverstärker (110) und dem Sigma-Delta-Modulator (112) aufweist.

2. Mikrofonanordnung (103) nach Anspruch 1, wobei die Filtereinrichtung (109) im Signalweg verhindert, daß niederfrequente Komponenten den Sigma-Delta-Modulator (112) erreichen.

3. Mikrofonanordnung (103) nach Anspruch 1 oder 2, wobei die Filtereinrichtung ein Hochpaßfilter (109) ist.

4. Mikrofonanordnung (103) nach Anspruch 1 oder 2, wobei die Filtereinrichtung ein Bandpaßfilter ist.

5. Mikrofonanordnung (103) nach einem der Ansprüche 1 bis 4, ferner mit einem Verstärker im Signalweg zwischen der Filtereinrichtung (109) und dem

Sigma-Delta-Modulator (112), um die gefilterten analogen Tonsignale zu verstärken.

6. Mikrofonanordnung (103) nach einem der Ansprüche 1 bis 4, wobei der Vorverstärker (110) und der Sigma-Delta-Modulator (112) auf einem Chip integriert sind, um eine monolithische integrierte Schaltung zu bilden.

7. Mikrofonanordnung (103) nach einem der Ansprüche 1 bis 4, wobei der Vorverstärker (110), der Sigma-Delta-Modulator (112) und mindestens ein Teil der Filtereinrichtung (109) auf einem Chip integriert sind, um eine monolithische integrierte Schaltung zu bilden.

8. Mikrofonanordnung (103) nach einem der Ansprüche 1 bis 4, wobei der Vorverstärker (110), der Sigma-Delta-Modulator (112) und mindestens ein Teil der Filtereinrichtung (109) auf getrennten Chips implementiert sind, um getrennte elektronische Schaltungen zu bilden.

9. Mikrofonanordnung (103) nach Anspruch 5, wobei der Verstärker Teil einer monolithischen integrierten Schaltung bildet, die ferner den Vorverstärker (110), mindestens ein Teil der Filtereinrichtung (109) und den Sigma-Delta-Modulator (112) aufweist.

10. Mikrofonanordnung (103) nach einem der vorstehenden Ansprüche, wobei der Wandler (108) eine flexible Membran mit einer Druckausgleichsöffnung aufweist, die die Membran durchdringt.

11. Mikrofonanordnung (103) nach Anspruch 10, wobei die Druckausgleichsöffnung solche Abmessungen hat, daß Frequenzen in den analogen Tonsignalen unterhalb eines vorbestimmten Frequenzwerts unterdrückt werden.

12. Mikrofonanordnung (103) nach Anspruch 6 oder 7, ferner mit einem digitalen Filter zum Empfangen von Daten vom Sigma-Delta-Modulator (112), wobei das digitale Filter Teil der monolithischen integrierten Schaltung bildet.

13. Mikrofonanordnung (103) nach Anspruch 12, wobei das digitale Filter ein digitales Dezimationstiefpaßfilter ist.

14. Mikrofonanordnung (103) nach einem der vorstehenden Ansprüche, wobei der Wandler ein Wandler auf Si-Basis ist.

15. Tragbare Einheit mit:

einer Mikrofonanordnung (103) nach einem der vorstehenden Ansprüche, wobei die Mikrofonanordnung (103) mit einem reinen Digitalsignalprozessor (114) zur weiteren Signalverarbeitung verbunden ist.

16. Tragbare Einheit nach Anspruch 15, wobei die tragbare Einheit aus der Gruppe ausgewählt ist, die aus Hörhilfen, assistierenden Abhörvorrichtungen, mobilen Aufzeichnungseinheiten, z. B. MP3-Playern; und Mobilkommunikationseinheiten, z. B. Mobil- oder Funktelefonen, besteht.

Revendications

1. Ensemble (103) de microphone, comprenant :

- un boîtier (104) pour ensemble de microphone, ayant un port (106) d'entrée sonore ;
- un transducteur (108) destiné à recevoir des ondes acoustiques à travers le port (106) d'entrée sonore, et à convertir les ondes acoustiques reçues en signaux audio analogiques, ledit transducteur (108) étant positionné à l'intérieur du boîtier (104) pour ensemble de microphone ;
- un circuit électronique positionné à l'intérieur du boîtier (104) pour ensemble de microphone, ledit circuit électronique comprenant un chemin de signal défini par une cascade
  - d'un pré-amplificateur (110) destiné à amplifier des signaux audio analogiques provenant du transducteur (108), et
  - d'un modulateur sigma - delta (112) destiné à fournir des signaux audio numériques,

caractérisé en ce que l'ensemble (103) de microphone comporte en outre un moyen (109) de filtrage dans le chemin de signal entre le pré-amplificateur (110) et le modulateur sigma - delta (112).

2. Ensemble (103) de microphone selon la revendication 1, dans lequel le moyen (109) de filtrage dans le chemin de signal empêche les composantes basse fréquence d'atteindre le modulateur sigma - delta (112).

3. Ensemble (103) de microphone selon la revendication 1 ou la revendication 2, dans lequel le moyen de filtrage est un filtre passe-haut (109).

4. Ensemble (103) de microphone selon la revendication 1 ou la revendication 2, dans lequel le moyen de filtrage est un filtre passe-bande.

5. Ensemble (103) de microphone selon l'une quelconque des revendications 1 à 4, comprenant en outre un amplificateur dans le chemin de signal en-

tre le moyen (109) de filtrage et le modulateur sigma - delta (112) de manière à amplifier les signaux audio analogiques filtrés.

6. Ensemble (103) de microphone selon l'une quelconque des revendications 1 à 4, dans lequel le préamplificateur (110) et le modulateur sigma - delta (112) sont intégrés sur une puce de manière à former un circuit intégré monolithique.

7. Ensemble (103) de microphone selon l'une quelconque des revendications 1 à 4, dans lequel le préamplificateur (110), le modulateur sigma - delta (112), et au moins une partie du moyen (109) de filtrage sont intégrés sur une puce de manière à former un circuit intégré monolithique.

8. Ensemble (103) de microphone selon l'une quelconque des revendications 1 à 4, dans lequel le préamplificateur (110), le modulateur sigma - delta (112), et au moins une partie du moyen (109) de filtrage sont mis en oeuvre sur des puces séparées de manière à former des circuits électroniques séparés.

9. Ensemble (103) de microphone selon la revendication 5, dans lequel l'amplificateur fait partie d'un circuit intégré monolithique comprenant en outre le pré-amplificateur (110), au moins une partie du moyen (109) de filtrage et le modulateur sigma - delta (112).

10. Ensemble (103) de microphone selon l'une quelconque des revendications précédentes, dans lequel le transducteur (108) comporte un diaphragme souple ayant une ouverture à égalisation de pression pénétrant le diaphragme.

11. Ensemble (103) de microphone selon la revendication 10, dans lequel l'ouverture à égalisation de pression a des dimensions telles que les fréquences dans les signaux audio analogiques au-dessous d'une valeur prédéterminée de fréquence sont supprimées.

12. Ensemble (103) de microphone selon la revendication 6 ou la revendication 7, comprenant en outre un filtre numérique destiné à recevoir des données depuis le modulateur sigma - delta (112), ledit filtre numérique faisant partie du circuit intégré monolithique.

13. Ensemble (103) de microphone selon la revendication 12, dans lequel le filtre numérique est un filtre numérique passe-bas de décimation.

14. Ensemble (103) de microphone selon l'une quelconque des revendications précédentes, dans lequel le transducteur est un transducteur à base de silicium.

15. Unité portable comprenant

- un ensemble (103) de microphone selon l'une quelconque des revendications précédentes, ledit ensemble (103) de microphone étant connecté à un processeur de signaux (114) purement numérique pour un traitement des signaux supplémentaire.

16. Unité portable selon la revendication 15, dans laquelle l'unité portable est sélectionnée à partir d'un groupe composé d'appareils de correction auditive, de dispositifs d'assistance audio, d'unités mobiles d'enregistrement, telles que des lecteurs MP3 ; et d'unités de communication mobile, telles que des téléphones mobiles ou cellulaires.

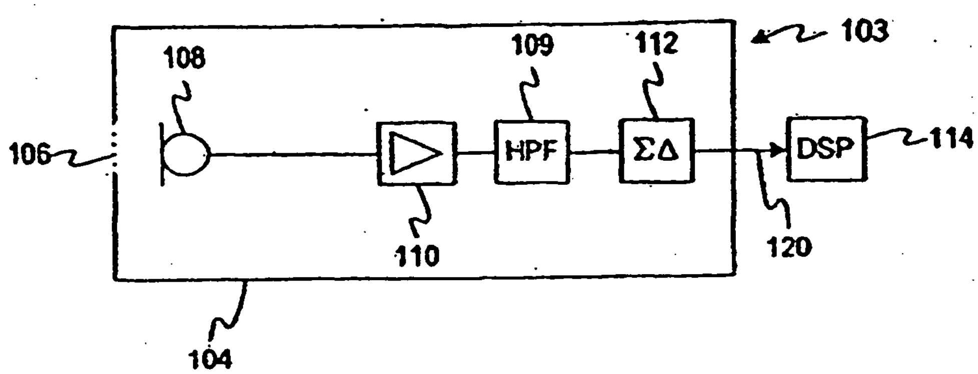
103
108
109
112
106
HPF
ΣΔ
DSP
114
110
120
104

Fig. 1

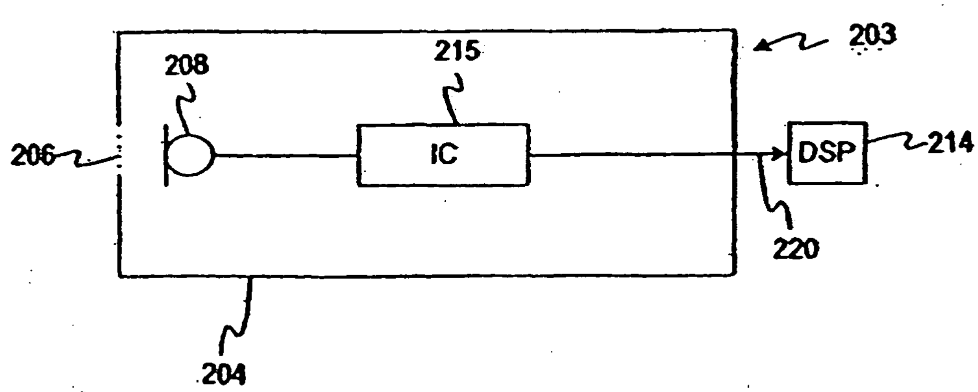
203
208
215
206
IC
DSP
214
220
204

Fig. 2